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The Challenge of Sustainability: Balancing China's Energy, Economic and Environmental Goals

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ABSTRACT

In recent years, China has experienced rapid economic growth and equally rapid increases in energy use. As a result, energy-induced environmental degradation has also increased in China, especially in its urban areas. When this fact is coupled with China's requirement for further economic expansion to meet the growing needs of its population, it is clear that the country faces great challenges in balancing its goal of economic growth with environmental sustainability. This paper suggests that an alternative energy path emphasizing energy efficiency and renewable energy development can be in China's long-term economic and environmental interest.

Since the late 1970s, Asian economic growth has outpaced that of any other region in the world. While the world economy grew at an inflation-adjusted average rate of 2.8% per year during 1980-1991, Asian countries[1] increased their annual GNP by 5.5%. China's performance was even more impressive, with the country's GNP growing at an extraordinary 9.3% per year during the same period (World Bank, 1993). This pace of change – over 3 times the world average and nearly twice the rest of fast-growing Asia – is virtually unparalleled in the 20th century.

Exceptional economic growth has been accompanied by similarly rapid growth in commercial energy use. While world energy use increased on average 2.5% per year, between 1980 and 1991, energy use by the same Asian countries climbed more than twice as fast (5.7 %). China nearly matched this growth rate, increasing its annual energy use at only a slightly less rapid rate of 5.3 % (World Bank, 1993). On a per capita basis, the difference between the rest of the world and Asia generally, and China specifically, is even more dramatic. During 1980-1991, worldwide per capita energy consumption rose at less than 0.8 % per year, but Asia's per capita energy use grew almost six times faster, at 4.4%, and China's grew at five times the world average – 3.8 % per year (World Bank, 1993).

Energy-intensive economic growth in developing countries has often been accompanied recently by a second, related trend of mounting air quality problems. The negative effects have been especially evident in large cities where large amounts of fossil fuel are consumed. This is particularly true in China because most energy supply facilities are located in or near large cities (Byrne *et al*, 1993). As a result, China's urban populations are exposed to a multitude of air pollutants, often at levels that are well above World Health Organization guidelines (World Resource Institute, 1994a). Most of these pollutants are by-products of coal combustion, as coal provides three-fourths of the country's commercial energy use and 70% of the coal used in China is bituminous with a sulfur content ranging as high as 7% (Liu *et al*, 1992). When this fact is coupled with China's requirement for further economic expansion to meet the growing needs of its population, it is clear that China faces great challenges in balancing its goal of economic growth with environmental sustainability.

Clearly, China will increase its energy consumption in order to sustain rapid economic growth. In this respect, the key question facing China, as well as other Asian developing countries, is not whether increased energy consumption is necessary. Rather, it is whether this increase will occur within an energy-efficient and environmentally sensitive development system or whether China will reproduce the past errors of already industrialized countries and remain highly energy inefficient until much later in its industrialization.[2] There is increasing evidence that economic competitiveness and the recovery of a healthy environment hinge upon this choice. With high- and upper middle-income countries delinking economic growth and energy consumption through the introduction of higher efficiency technologies and integrated resource planning approaches (Wang *et al*, 1988), it is a critical time for energy planners in China.

Drawing from Chinese national data, as well as the research and experience of the authors with China's energy system and policies, this paper identifies specific steps for moving China toward a sustainable energy system. Our analysis is presented in four stages. First, China's economic growth, energy intensity and air pollution problems in the last decade are documented. Second, international studies that indicate a decoupling of energy use and economic growth through improved energy efficiency are examined; and China's progress in improving industrial energy efficiency is reviewed. Third, energy efficiency and renewable energy options as economic and environmental alternatives are discussed. We conclude by recommending specific policy options to realize the country's significant potential in the areas of energy efficiency and renewable energy.

ENERGY, ENVIRONMENT AND DEVELOPMENT LINKAGES

Rapid economic and energy growth in Asia has brought significant improvement in the quality of life to the region. However, Asia has simultaneously become the one of the most energy-intensive manufacturing regions in the world. China is one of the most intensive among Asian countries. Although, intensities of energy use vary in China by sector,[3] the country on average requires three or four times as much energy input per unit of output as the developed countries (*China's Agenda 21*, 1994).

In one respect, this is no surprise. China's industry is now more concentrated on processing raw materials and the production of infrastructure and durable goods, all of which are highly energy-intensive activities. Historically, early stages of industrial development have brought rapid escalations in commercial energy use. The first country to industrialize in the modern era – Great Britain – saw its energy intensity of production grow by several orders of magnitude before falling even more than it had risen. This pattern was repeated in the case of Germany, France, the U.S. and Japan (Reddy and Goldemberg, 1991). It is likely that Asia generally, and China specifically, will follow this pattern.

But there are two aspects of the contemporary situation that should be causes for concern in China's case. First, globalization of markets means that China must compete increasingly with production lines in other countries that are far less energy-intensive. China's competitive edge may be jeopardized unless improvements in energy efficiency are more quickly introduced. Additionally, the environmental toll will escalate if the conventional energy course continues. Both issues are examined below.

Energy-Economy Linkages

The world economy today is far more significant in affecting national development than was the case for Britain, Germany, the U.S. or other countries that industrialized. While China's domestic economy is one of the largest in the world[4] (and growing) and, therefore, may not need to depend as much as other countries on trade, nonetheless the country's high energy intensity of industrial production (e.g., in its chemical and steel industries) may place China at a competitive disadvantage in world markets. Indeed, the industrialized countries have actively moved heavy industrial production (such as steel and petrochemicals) to the Pacific basin. If China is to be competitive over the long term, it is essential that its energy intensities decline soon, before other countries are able to exploit their comparative energy efficiency advantage to capture emerging markets and technologies.

High energy intensities have significant implications for energy supply as well. While China has large coal reserves, it is important to recognize that they are not large on a per capita basis. Indeed, China's coal wealth **on a per capita basis** is lower than the world average –– 248 metric tons for China compared to 369 tons for the world as a whole. If the proved recoverable reserves are included, Chinese coal resources per capita are only one-half the world average – 99 vs. 196 metric tons (World Resource Institute, 1994a). The modest size of per capita fossil fuel reserves restricts China's capacity to follow western-style industrialization. Thus, if China is to meet its aims of economic expansion for its growing population, its energy intensity must be reduced in the near future.

The developed countries are in the process of delinking their economic growth from energy use. An international comparison of energy intensity among several income groups (using World Bank definations[5]) shows a trend toward economic growth based on decreasing energy consumption for developed countries (see Figure 1). This pattern has important positive implications for the environment and for energy supply. But it is also a signal of the urgency of the need for action among developing countries to adopt less energy-intensive development strategies.

Figure 1 shows an inverse relation between country income and energy requirements for development during the 1971-1991 period. Low-income countries (i.e., those with GDP per capita less than US $500) exhibit a much higher level of energy intensity, roughly three times that of any other income group, in every time period. Conversely, energy intensity among high-income countries has continuously declined since the oil crises of the 1970s. Upper-middle-income countries reached their energy intensity peak in the early 1990s and may soon begin to reduce their energy requirements of production.

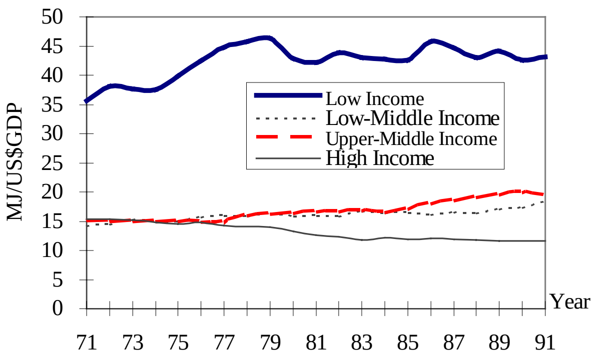

FIGURE1: ENERGY INTENSITY TRENDS OF SELECTED INCOME GROUPS

Source: World Resources Institute, 1994b

Many argue that comparisons among countries on energy intensity are affected by a variety of factors, such as economic systems, energy structures, and a combination of spatial, historical and cultural contexts (Smil, 1994). As a result, comparisons among countries using this indicator can be fraught with interpretive problems. Yet, the general trend of an inverse relation between economic growth and energy requirements for development is probably an important one to recognize in the evaluation of energy policy options for developing countries, Specifically, it raises the possibility that economic growth can be achieved by smaller (and, eventually, negative) energy consumption growth through the aggressive pursuit of energy efficiency.

Recent trends in China suggest that progress is being made in reducing the nation’s energy intensity of output. During the initial stage of China's industrial development (before 1978), the growth rate in energy consumption was reater than that of the economy. After 1978, a series of energy policies were formulated to promote energy efficiency. As a result, energy consumption growth slowed while economic growth rates continued to climb (see Figure 2).

But despite the impressive success of China's industrial energy policies, the country ended the 1980s with one of the highest ratios of energy input per unit of output in the world, indicating that the country has a long way to go before its industrial production achieves world levels of energy efficiency.

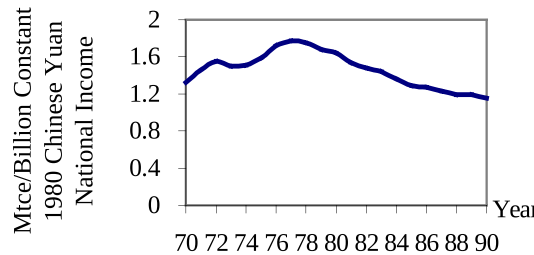

FIGURE 2: ENERGY INTENSITY OF THE CHINESE ECONOMY, 1970-1990

Source: Levine et al, 1992

Energy-Environment Linkages

A second challenge for China concerns the environmental impacts of rapid, energy-intensive, economic growth. One basic indicator of the problem is the level of urban air pollution. According to data from China's air quality monitoring network, the average suspended particulate matter (SPM) concentration in 1989 reached 432 $\mu g/m^3$ for all its cities combined; and was 526 $\mu g/m^3$ in northern cities, and 318 $\mu g/m^3$ in southern cities. The SO_2 annual average in 1989 reached 105 $\mu g/m^3$ for all cities, 93 $\mu g/m^3$ and 119 $\mu g/m^3$ in northern and southern cities, respectively (Xu and Hao, 1993). These concentrations are well above the World Health Organization standards for healthy urban air.[6] Nearly all of this problem can be traced to fossil-fuel combustion. China emitted almost 20 million tons of SPM and 16.8 million tons of SO_2 in 1992 (China State Statistical Bureau, 1993). The former is nearly three times what the U.S. now produces - 7.4 million tons (World Resource Institute, 1994a) and the latter accounts for 16 % of world annual SO_2 emissions (Ryan and Flavin, 1995). Urban air pollution associated with these emission levels in China is most serious in winter and spring due to coal-burning for heat, in addition to electricity generation and factory production.

International comparisons also reveal striking evidence of declining environmental quality in urban China. According to the World Health Organization and the U.N. Environment Program, five of the 10 mega-cities with the world's highest SPM are in China – Shenyang, Xian, Beijing, Shanghai and Guangzhou. With regard to SO_2, three of the 10 mega-cities with the highest monitored concentrations are in China – Shenyang, Guangzhou and Beijing (WHO and UNEP, 1989).

With high SO_2 emissions comes another environmental threat – acid rain. Rapid development in China is creating one of the world's most serious acid rain problems (Smil, 1993). Based on estimates by China's National Environmental Protection Agency, rainfall acidity has increased not only in urban areas, but also in most rural parts of China. The acid rain problem has extended to the region beyond both the Yangtze and the Yellow Rivers, and now encompasses an area of 2.8 million km^2. This represents an increase of 60 percent over the 1985 figure of 1.75 million km^2 (*People's Daily*, 10 January 1995).

These high pollutant concentrations in China's air and rainfall are a direct outgrowth of the country's reliance on high-sulfur coals and inefficient energy systems to power its economy. It is reported by the State Economic and Trade Commission that 90 percent of SO_2, 85 percent of CO_2, 87 percent of NO_x, and 70 percent of particulate in Chinese cities come from direct burning of coal (Li, 1995). The environmental implications of energy-intensive, fossil fuel-based development bring into even sharper focus the need for China to change its energy course. Of course, China's reliance on a coal-based energy system cannot be quickly changed; indeed, it will take several decades before major reductions in China's reliance on coal resource can be seen. However, China can capture significant economic and environmental benefits by immediately moving toward a high-efficiency energy system and seeking more rapid development of its renewable energy wealth.

ENERGY EFFICIENCY AND RENEWABLES AS ECONOMIC ALTERNATIVES

Over the last decade, China has made important progress in reducing the energy intensity of its industrial production. Since 1980, energy consumption in China has grown by about 80%. But GNP has increased by more than 200%. Typically, industrializing countries have ratios of energy to economic growth greater than 1.0. Key to this progress were ambitious energy conservation programs included in the sixth and seventh Five-Year Plans (1981-85 and 1986-90). By 1990, an estimated 280 million tons of coal equivalent had been saved as a result of the conservation programs in these two plans (*People's Daily*, 8 October 1993). Since China continues to experience energy supply shortages (estimated to be over 170 billion kWh - see the *World Journal*, 23 February 1994), these savings have been realized in the form of **avoided** economic losses that would have occurred without improvements in energy efficiency. That is, if China had not successfully launched its energy conservation programs, energy shortages would have been greater, leading to idled industrial capacity and the loss of economic output.

Using the experience of energy-efficiency programs launched during the sixth Five-Year Plan (1981-1985), economic benefits can be shown to accrue to China as a result of its investment in this option. According to Levine and Liu (1990), for example, it cost approximately 400 yuan[7] to add the energy equivalent of one ton of coal to the capacity of China's energy system for the 1981-1985 period. However, estimates of the cost of saving the equivalent of one ton of coal range from 50 to 340 yuan for the country's technology modernization projects. For example, improvements in domestic coal-burning efficiency cost 100 yuan to save the equivalent of one ton of coal; the renovation of industrial furnaces and boilers cost 140 yuan and 250 yuan, respectively. Overall, China's 8.2 billion yuan investment in energy-efficiency in the sixth Five-Year Plan (1981-1985) is calculated to have saved energy at the rate of 290 yuan per ton of coal equivalent; or 73% of what it would have cost the country to supply the same amount of energy through its current system (Levine and Liu, 1990).

While China's success in improving energy efficiency deserves praise, there are still many opportunities for cost-effective investment in energy efficiency. In fact, China's existing energy system remains highly inefficient, due in large part to the direct use of low-quality coals in end-uses. Coal intensity is particularly true in the country's urban areas as coal is a primary resource used for cooking and heating. For example, coal supplied about 75% of energy requirements per person in 1991, compared with 14% from electricity (China State Statistical Bureau, 1994); Based on a national survey, coal stoves with thermal conversion rates ranging from 0.15 to 0.3, were used by 60% of China's urban population in 1990 (Li, 1992).

In addition to the country's many cost-effective opportunities to improve energy efficiency, China also has a number of renewable energy alternatives. Renewable resources are sometimes mistakenly regarded to be a modest contributor to energy supply. An assessment made just a decade ago estimated that U.S. wind resources were capable of providing only 10% of U.S. energy needs. Now, based on more precise resource surveys completed recently, experts have concluded that wind from just a few states in the midwestern part of the United States is sufficient to provide the electricity needs of the entire country. Total U.S. wind resources, assuming moderate restrictions on land use, could provide 10,800 TWh per year, or 384% of current U.S. generation (Grubb and Meyer, 1993), typically at a cost of less than 6.0 cents per kWh (Cavallo *et al*, 1993).

Given China's abundant renewable resources, the development of an energy system fueled by renewable energy is hardly far-fetched. According to the Chinese Government (*China's Agenda 21*, 1994), the nation's geothermal reserves are equivalent to 3 billion tons of coal equivalent, but only 0.01 per cent of this resource is being tapped. China's total wind power potential is estimated at 1,600 GW. This is over 8 times current Chinese electricity generation capacity. If this resource can be harnessed, at least in some regions, at 6.0 cents per kWh, this would provide users relatively low cost power without adverse environmental impacts. Similarly, the prospect for photovoltaic (PV) technology in China is strong. Most parts of China receive quite high levels of solar radiation, averaging 1,668 kWh per square meter annually (*China's Agenda 21*, 1994). A recent study, conducted by the Center for Energy and Environmental Policy of the University of Delaware on the economic viability of household and community scale PV, wind and PV-wind hybrid systems in the Inner Mongolia Autonomous Region of China, indicates that stand-alone renewable energy systems can provide year-round electricity service to remote rural areas at a lower cost than conventional diesel or gasoline gen-sets and grid extension to supply power (Byrne *et al*, 1996). Renewable energy technology such as PV can also be deployed in the urban building sector either as a direct load control device or as a peak-shaving tool (Byrne *et al*, 1995). China has installed thousands of small scale wind turbines (less than 20kW) with a total capacity of 30 MW in several provinces and plans to increase this capacity to 1 GW by the year 2000 (Zheng, 1995). China has also built its first 100kW PV power station in Qinghai Province (*People's Daily*, 25 October 1993) and the country currently has the ability to produce 5 MW of solar cells annually (Zhou *et al*, 1995). These provide a good beginning, but more can be done to develop these renewable energy technologies.

Strategic use of renewable sources can improve the overall efficiency of China's energy system in two ways. First, renewables reduce fuel risks because, unlike fossil fuels, there is no variability in the fuel cost of these energy sources. Thus, renewable energy can contribute diversity in fuel supply while offering some protection from sudden changes in domestic or international fuel prices. Second, renewable sources typically are not dependent on economies of scale for their development. Instead, they can be scaled to current load needs and, subsequently, expanded to meet new growth in demand. This feature, commonly termed modularity, means that renewables can be given increased priority when use of fossil technology would be too expensive due to the relatively small scale of demand, or when fuel costs (including transportation) are prohibitive.

ENERGY EFFICIENCY AND RENEWABLES AS ENVIRONMENTAL ALTERNATIVES

In addition to their economic value, energy efficiency and renewable energy offer important health and environmental benefits that justify investing China's engineering talent and creativity, as well as scarce capital, in their rapid development. One clear area to focus attention on is China's coal-burning practices. The widespread use of coal as a heating fuel for urban buildings and an industrial feedstock is inherently problematic from an environmental point of view. In the "best" of circumstances, this fuel's use can lead to major air pollution and solid waste disposal problems. Inefficient use of coal only exacerbates an already significant tendency toward environmental degradation. In China, the problem is becoming acute because a large portion of the coal burned in China is not sorted or washed.

Just as energy efficiency may be a more economical way of meeting energy needs for economic growth, many times it can also provide environmental benefits more effectively than postponing action and trying later to backfit technology to remove pollution. Analyses conducted in the U.S. have indicated that investment in end-use efficiency in lighting and refrigeration can be much cheaper than investment in retrofit technology as a means of reducing SO_2 emissions (see Table 1).

Of course, environmental cleanup in China's urban areas must not be neglected. Investment in combustion technology and industrial retrofits is much needed for controlling the pollutants. Estimates of economic losses attributable to environmental pollution have been put at 100 billion yuan each year in China (Qu, 1994). However, the substantial environmental advantage of avoiding a ton of SO_2 through energy efficiency, especially from a social perspective, underscores the point that inaction on energy efficiency can be costly to China's environment and the health of the people.

TABLE 1: COSTS OF REDUCING SO_2 EMISSIONS

	US$ Per Ton of SO_2 Removed (Avoided)
Retrofit Technology	
Wet FGD Technologies	578 - 984
Dry Injection Technologies	541 - 869
End-Use Efficiency	
High Efficiency Refrigeration	328 - 541
High Efficiency Lighting (CFL)	106 - 160

Source: Temple, Barker and Sloan, 1990.

Similarly, China can secure significant environmental benefits by substitutions of renewable energy for coal where possible. For example, if China converted three percent of its wind energy potential to electric generation (it is estimated by the Chinese Government that about 10 percent of the country's wind potential is utilizable - see *China's Agenda 21*, 1994), this would represent approximately 25 percent of the country's current electricity generation and would avoid 193 million tons of CO_2, and 3.7 million tons of SO_2 emissions annually.[8] These avoided emissions equal 10 % of the country's annual CO_2 releases and about 22 % of its yearly SO_2 releases. Similar results could be attainable from the exploitation of the country's geothermal, biomass and solar energy. Thus, greater use of renewables in the energy system can offer sizable environmental benefits to China.

POLICIES FOR REALIZING THE POTENTIAL OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Since China is in the process of assembling its infrastructure for the 21st century, this is a critical time for developing energy efficiency and renewable energy in its end-use sectors – buildings, transportation, industrial processes and agriculture. To enable energy efficiency and renewables to compete on a level playing field, China needs to reform several features of the existing institutional and economic structure. First, China's energy planning should begin to set goals and timetables for increasing the use of renewable energy resources in areas where grid extension is too costly and where opportunities for the use of renewables is economically warranted. China has, arguably, the most rapidly transforming economic system in the world. Indisputably, it is undergoing the largest economic transformation of the 20th century. Setting aggressive goals for energy efficiency and renewable energy use will help to assure that social and environmental opportunities are realized in concert with economic ones.

Second, China needs to institutionalize its development of energy efficiency and renewable energy. The country has made the first step in this direction by creating an energy efficiency center - Beijing Energy Efficiency Center (BeCon) in 1994 with financial support from the U.S. The Chinese government needs to make a more extensive commitment to the establishment of an institutional framework to support energy efficiency and renewable energy development. Correspondingly, China should promote province-based collaboratives to identify energy efficiency and renewable energy opportunities and to document barriers. The country also needs to encourage government-industry partnerships to commercialize energy efficiency and renewable energy technologies.

In addition to building an institutional framework, China should also adopt specific regulatory measures. Establishment of comprehensive national air-quality standards and creation of national energy-efficiency codes can furnish the driving force for rapid development of the country's energy efficiency and renewable energy opportunities. Adoption of integrated resource planning principles by the central government is another needed regulatory action. This would go a long way toward promoting province-based integrated resource planning efforts.

To stimulate the development of energy efficiency and renewable energy, China needs to also enact several incentive policies. A critical step in this direction is the gradual end to government subsidies for fossil fuels. The creation of an avoided cost mechanism for resource evaluation and the development of utility-based rebate programs to encourage the utilization of high efficiency and renewable energy technologies should be high priorities of national energy policy. Time-of-use and other cost-based pricing in the electricity sector will also help China to move toward a sustainable energy future. Finally, tax treatment of energy equipment expenditures needs to be adjusted to recognize that most renewable resources (e.g., wind and solar energy) have no fuel costs to be deducted from revenues for tax purposes. Sliding-scale tax credits at the provincial and local levels would be one means of spurring early investment in China's substantial renewable energy potentials. Together, these incentive-based actions -- the elimination of subsidies for fossil fuels, the establishment of an avoided cost mechanism, the creation of efficiency and renewables rebates, the adoption of cost-based electricity pricing and the reform of tax laws relating to energy investments -- will create the "level playing field" needed to enable alternative energy to compete in China's fast-changing energy market.

Along with the above incentive options, China needs to examine market transformation strategies that will encourage more rapid development of its energy efficiency and renewable energy potential. One important option includes province-based renewable energy set-asides in which local governments set targets for increased use of renewable energy. Such a strategy will quickly identify least-cost applications and, in parallel, stimulate focused technology development to meet emerging markets. A second option would be to support policy collaboratives involving governments, industry, community and research organizations in the identification of local energy efficiency and renewables markets that could be encouraged to grow by policy and institutional reforms.

Finally, China needs to enhance its cooperation with the international community to promote the country's energy efficiency and renewable energy development. For example, China should seek capacity-building and institutional support from multilateral organizations, including the World Bank, the Global Environmental Facility (GEF), and the United Nations Development Programme (UNDP). In addition, China should take advantage of global environmental quality monitoring to target its energy efficiency and renewable energy development initiatives. China should also take action to clearly define the institutional basis for cooperation with developed countries for the transfer of energy efficiency and renewable energy technologies. Finally, China should participate actively in worldwide information exchanges on energy efficiency and renewable energy options.

CONCLUSION

Economic development is now and will remain a dominant goal for China. However, it is possible to achieve the country's goals in a sustainable way. Pursuing an alternative energy path emphasizing efficiency and renewables can be in China's long-term economic and environmental interest. Energy efficiency and renewable energy can help to continue China's economic development without further depleting the country's limited fuel reserves or harming the environment and human health. Several industrial countries are actively pursuing energy efficiency and renewable energy options. China can move quickly in this direction because it can invest in efficiency and renewability from the outset, rather than having to rebuild its energy system as industrial countries must do.

Undoubtedly, the development challenges faced by China are great. However, these challenges can be met if principles of sustainable development inform the nation's economic, energy and environmental policy, and if international support is mobilized to meet its needs. Together, China and the world community can produce the new ideas and enact the innovative policies that will realize a sustainable future.

FOOTNOTES

[1]Includes all countries in East, South and Southeast Asia except Japan. Excludes central Asian countries which were part of the former USSR.

[2]On the energy-inefficient history of the U.S. and Europe, see Melosi, 1992 and Greenberg, 1992.

[3]For example, in 1992, coal-related products consumed 8.48 tons of coal equivalent (tce) commercial energy to create 10,000 yuan of output. This was followed by chemical (5.58 tce), building material (5.36 tce), and ferrous metal industries (5.32 tce), respectively. In comparison, average energy consumption per 10,000 yuan of output in machine, electric, and electronic industries is only 0.68 tce and energy intensity in the textile industry is 0.9 tce per 10,000 yuan of output (China State Statistical Bureau, 1993, 1994). One yuan in 1992 was equal to US $ 0.19.

[4]In 1991, China's total GNP and purchasing power parity were the eleventh and third highest, respectively, among 151 countries (World Resource Institute, 1994).

[5]For definitions of income groups, see World Bank, 1973, 1983, 1993. The former Soviet Union, most Eastern European countries, and OPEC member countries are excluded from Figure 1 due to the lack of data.

[6]The World Health Organization's standards for healthy urban air are concentrations of less than 60-90 $\mu g/m^3$ for SPM and 40-60 $\mu g/m^3$ for SO_2 (World Resource Institute, 1994).

[7]One Chinese yuan was equivalent to approximately US$ 0.27 between 1986-88, US$ 0.19 between 1989-93, and currently equals to $ 0.11.

[8]This calculation is based on the estimates of emissions from a typical U.S. pulverized coal power plant without scrubbers: CO_2: 884 g/kWh and SO_2: 17.2 g/kWh. See Flavin and Lenssen, 1994. Environmental benefits can be expected to be greater in China, considering the relatively inefficient technologies on which the country's energy system is currently based.

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